Holographic Projection of Structured Beams of Light for Target Ranging, Remote Velocimetry, and Sample Acquisition

Completed Technology Project (2015 - 2016)

Project Introduction

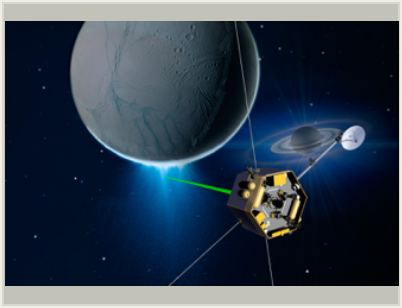
Structuring the amplitude, phase and polarization profiles of a laser beam can endow the light with remarkable properties that create immediate opportunities for applications ranging from LIDAR to optical trapping. This proposal seeks support to develop a programmable holographic projection and detection system that will make practical use of recent advances in the theory of vector beams of light to project non-diffracting laser modes with properties that are desirable for both long-range environmental sampling and LIDAR applications. This will allow for the competitive merging of remote sensing, laser ranging, and sample collection in one next generation system that could be used to significantly increase value laser systems proposed for future NASA's high profile remote sensing, ranging, and sample collection missions.

This proposal intends to take an already existing laser-based optical beam trapping system and perform guided research with it to eventually enable missions that will be able to remotely target samples and study them over extended distances. This would be accomplished by conducting fundamental research in the field of optical trapping that would primarily focus on increasing the range and quality of the trapping beam so it will be practical for a mission. On top of the trapping capability of the technology being researched, it has become clear that it is possible to use the same fundamental system for velocimetry and laser ranging applications. By pursuing this IRAD GSFC can choose to use it the system for particle capture missions, docking operations, lander assist, or other ranging appliactions. This proposal intends to take advantage of collaboration between science PIs (MIT, GSFC) actively interested in using this technology as soon as it is matured, NYU fundamental research, and GSFC laser engineers capable of advancing the TRL of the system in order to meet the following short term goals, which will put the technology in better position to win future missions:

1. Meter-scale projection of vector modes with applications for transport and telemetry with the goal of reconstruction over cm level scales.
2. Programmable deflection of structured modes studying the quality of the beam as a function of angle for lidar applications.

Anticipated Benefits

The justification for investing in this laser trapping technology is two fold. First, the 2013-2022 National Research Council (NRC) Planetary Decadal Survey has several high profile missions featuring orbiters that will perform interstellar and atmospheric particle sampling as well as mass spectroscopy to be carried out by landers. A laser-based tractor beam system could add powerful remote sensing capabilities on both of these instruments and future systems by either grabbing desired targets from the upper atmosphere on an orbiter or by trapping particles from the ground or lower atmosphere from a



Conceptual image of a possible future mission using laser based trapping to capture ice plum particles emitting from Enceladus

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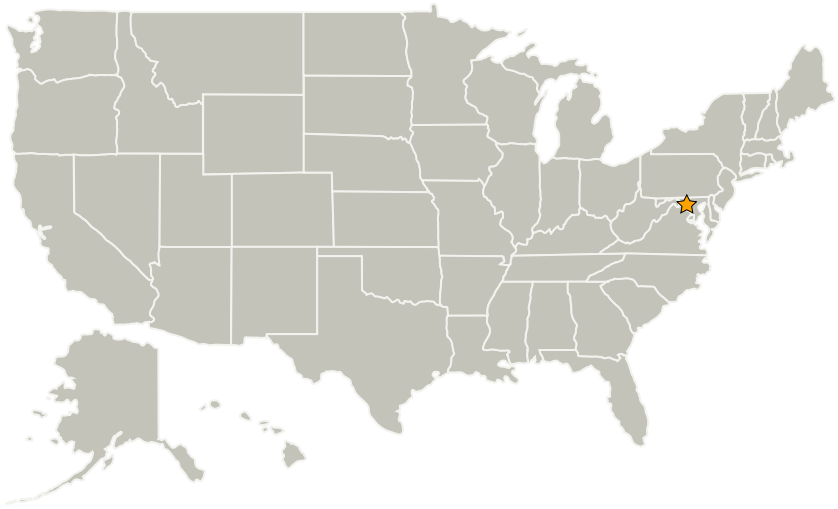
lander. A tractor beam could also significantly reduce the risk of rover and even eventual manned missions that involve sample collection because it could be used to study particles in currently unreachable or dangerous areas. Secondly, there has been much interest in advancing the state of technology of current 3-D imaging systems that assist with ranging for docking, space debris mitigation, and landing operations. Systems such as (LIRIS) Laser InfraRed Imaging Sensors (LIRIS) are currently being used on the ISS and will be leveraged for deep space docking operations (Mars capsule or Asteroid capture). Or consider that the 3D flash LIDAR being used for ranging on OSIRIS could be replaced by the system we are , which could both perform the ranging to the target and capture particles simultaneously. A Venture-class proposal could be developed where the same laser system could assist with docking an instrument on the International Space Station (ISS) and then immediately be repurposed to perform science by capturing comet particles that pass by regularly. This would be a relatively inexpensive proof-of-concept mission that would demonstrate capability before graduating to a free flyer or rover mission. The tractor beam ranger combination could be especially well suited for a free flyer mission for ranging to and capturing delicate targets such as ice plume particles emitting from Enceladus. Our research will focus on understanding and optimizing the current tractor beam's ability to gently capture difficult targets over a long range and to understand how well it will work as a ranging LIDAR compared to other currently used technologies. Once achieved this would be a powerful system that could provide both science and engineering laser activities vastly increasing the value of putting a laser on a mission.

Primary U.S. Work Locations and Key Partners



Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Goddard Space Flight Center (GSFC)

Responsible Program:

Center Innovation Fund: GSFC CIF

Project Management

Program Director:

Michael R Lapointe

Program Manager:

Peter M Hughes

Project Manager:

Matthew J Mcgill

Principal Investigator:

Paul R Stysley

Co-Investigator:

Ricardo Arevalo

Center Innovation Fund: GSFC CIF

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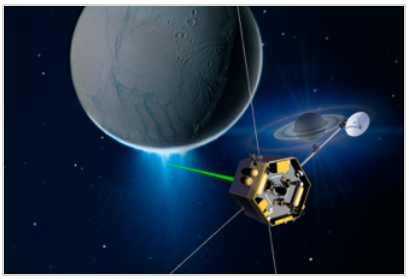
Organizations Performing Work	Role	Type	Location
★Goddard Space Flight Center(GSFC)	Lead Organization	NASA Center	Greenbelt, Maryland
New York University(NYU)	Supporting Organization	Academia	New York, New York

Images



Enceladus laser trapping mission concept
Conceptual image of a possible future mission using laser based trapping to capture ice plum particles emitting from Enceladus *(https://techport.nasa.gov/image/27737)*

Stories

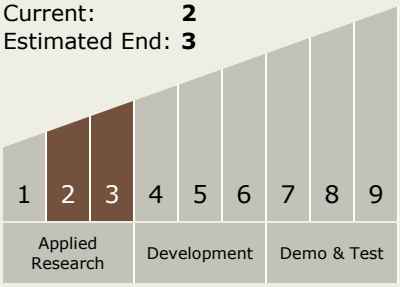
Meet the man working with NASA on a real-life tractor beam *(https://techport.nasa.gov/file/36708)*

Project Website:

http://sciences.gsfc.nasa.gov/sed/

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.5 Lasers